

STUDYING THE EFFECT ADDITION OF OKRA-NATURAL MUCILAGE AS DRAG REDUCING AGENT IN DIFFERENT SIZE OF PIPES IN TURBULENT WATER FLOWING SYSTEM

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ABSTRACT

The problem of pumping power losses in pipelines carrying liquids and flowing in turbulent mode is one of the major challenges in the power saving field. Pumping power saving by the addition of minute quantities of additives to the main flow was applied in the present work. Natural drag reducing agent was prepared and extracted from okra fruit and it was tested in a closed loop of turbulence water flowing system. Flow tests were conducted using water as the carrying liquid. The experimental work starts by pumping water from reservoir tank that had mixed with mucilage was pumped with six different flow rates in two different pipe diameters (0.015, 0.025 m ID). The types of pipe used are galvanized iron pipe. The testing length of this flow system is 1.5 m. Objective to explain drag reduction differences between large and small pipes were successful. The results shows that, percentage drag reduction (Dr%) increases by increasing the concentration of Okra-Natural mucilage. Maximum Dr% of 71% was obtained using 1000 ppm of Okra-Natural Mucilage in water flow system.

Keywords: Drag Reduction, Okra, Natural mucilage, closed loop, galvanized iron pipe, Power saving

INTRODUCTION

Fossil fuel reservation nowadays is decreasing forces scientists and engineer to build energy-saving systems. Small amount of certain polymers added into water can reduce friction of the solvent in turbulent flow. Normally, liquids are transported in pipelines in a turbulence mode (Reynolds number higher than 2500) and that will lead to huge pumping power losses along the pipelines system. Drag Reducing Agent (DRA) were used in the past in order to improve the flow. The indicator for DRA efficiency is Drag Reduction (DR) value. Drag reduction in polymer solutions can be related with the equation derived by Virk by using pressure drop reading through testing section before and after natural polymer addition. These details were needed to calculate the percentage Drag Reduction DR% as follows (Virk, 1975).

$$Dr(\%) = \frac{\Delta P_b - \Delta P_a}{\Delta P_b} \times 100 \quad (1)$$

Polymer is a large molecule that built up from repeated small chemical units to become linked together. The conversion of monomers to polymer involves the rearrangement of electrons. Polymers also have different arrangement of molecules that resulting to form linear, branched or cross-linked structures. Polymer also can be natural polymer or synthetic polymer that synthesis from variation of chemicals. (De Gennes, 1990) has stated that polymer drag reduction is due to elasticity rather than viscosity. However, polymer can be easily degraded and lost their effectiveness in turbulent flow in short period even it is high molecular weight ($>10^5$). In this recent research, okra mucilage will be used as drag reducing agent (DRA). Okra mucilage is one of natural polymer. Okra is a plant came from mellow family. Its scientific name is *Hibiscus Esculentus* or *Abelmoschus esculentus*. Okra is available in many countries, inexpensive, renewable source stable in its chemical and physical properties, hydrophilic, a modifiable polymer and biodegradable (Chauhan et al., 2002). The mucilage obtained from okra pod are less than aloevera and higher than eggplant. Okra mucilage is polysaccharides that compose from D-galaktose, I-rhamnose, I-galacturonic acid (Mishra and Pal, 2008) and form slippery, aqueous colloidal suspension. It has very high molecular weight up to 200,000 and more.

MATERIAL AND METHODS

Pipe diameter, solution flow rate and additive concentrations were the variables investigated in the present study. Each set of experimental work deals with Okra Mucilage in water flowing in one of three pipe diameters within 5 addition concentrations and six different solution flow rates. This study was conducted in 2009 in Faculty of Chemical and Natural Resources Engineering, University Malaysia Pahang.

Okra-Natural Mucilage

Okra is the common name of *Abelmoschus Esculentus* (synonym *Hibiscus Esculentus*). Other common names are lady's finger, gumbo or bindi. Okra belongs to the Malvaceae Family. The flowers of the plant are hibiscus-like and after flowering edible capsules are formed. The fruit of okra is a pentagonal, narrow, cylindrical capsule, from 2-12 inches and contains a mucilaginous substance. Its mucilage is commonly used as a thickener in cooking. There is a long tradition of using okra in cooking as well as for medical uses. A pectin-like polysaccharide isolated from the mucilage from fruit pods of okra possesses viscoelastic properties, when dissolved in a physiological buffer, suitable to use as viscoelastic substances.

Preparation of Okra Mucilage

The immature okra fruit were purchased from a local market; a variety of okra noted for its sliminess was chosen. The seeds do not contain any mucilage and were removed prior to extraction. 100g of okra will be cut into pieces. Then, okra will be soaked with 1L of distilled water for 5 hours and then heated at 70°C for 5 min to inactivate enzymes. The soaked okra will produce mucilage that change clear water into very thick viscous. Then,

okra will be filtrated by muslin cloth to prevent any big colloidal and suspended solid to get through.

Flow System Description

The flow systems as shown in Figure 1 consist of reservoir tank, pipes, valves, pumps are constructed to present the current investigation requirements. The reservoir tank was supported with two exit pipes connected to centrifugal pumps. The first exit pipe with was connected to the main centrifugal pump which delivers the fluid to the testing sections. The other exit is connected to the other centrifugal pump for deliver excess solvent to reservoir tank. Two galvanized iron pipes of various inside diameters 0.015 and 0.025 m ID were used in constructing the flow system. A complete closed loop piping system was build. Piping starts from the reservoir tank through the pump, reaching a connection that splits the pipe into two sections. The first section returns to the reservoir tank, build up as bypass and the other splits into three sections with different pipe diameters at testing section. The testing sections were 1.5 m long and it was located about 50 times of pipe diameter. This is to ensure the turbulent flows are fully developed before the testing point. 2 set of Baumer Differential Pressure Gauge were used to detect the pressure drop in pipelines with maximum differential pressure reading up to 0.16 and 0.25 bars for both. In order to measure the flow rate of fluid in pipelines, Ultraflux Portable Flow Meter Minisonic P has been used. This ultrasonic flow meter measurement was sensitive with small changes in flow rate as low as 0.001 ms⁻¹ can be detected.

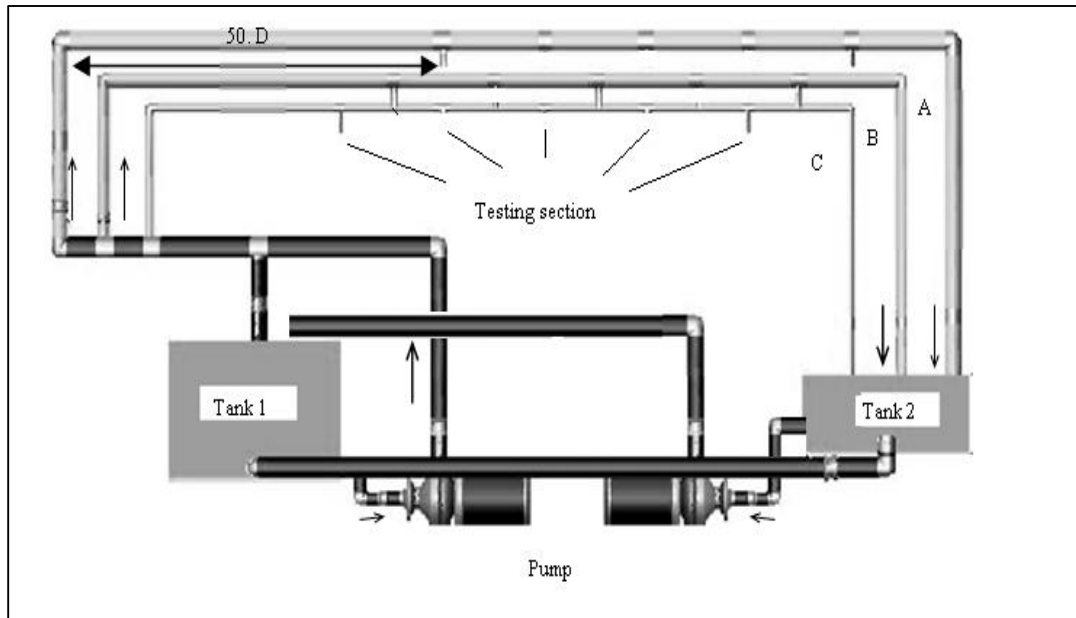


Figure 1: The experimental rig design

RESULTS AND DISCUSSION

The results of the experimental work showed that the percentage Drag reduction increases by increasing the transported fluid flow rate presented by Reynolds number (Re) as shown in Figures 2 and 3. This behaviour is due to the increase of the degree of turbulence that

provides a suitable media for the drag reducing agent to act efficiently in media by suppressing the turbulence structures formed. Increasing the degree of turbulence relates to the increasing the number of eddies that absorb the energy from the main flow to complete its shape. The diluted molecules of the okra-natural polymer added will be part of these eddies resulting new media of flow with the new addition. It will be more difficult for this eddies to form and complete its shape to its structure.

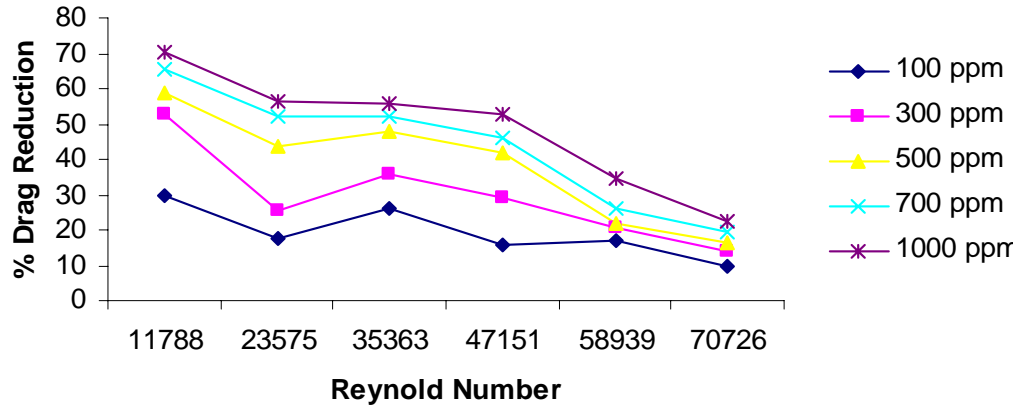


Figure 2: Effect of Reynolds number on percentage drag reduction for Okra-Natural Mucilage with different concentrations dissolved in water flowing through 0.015 m ID pipe

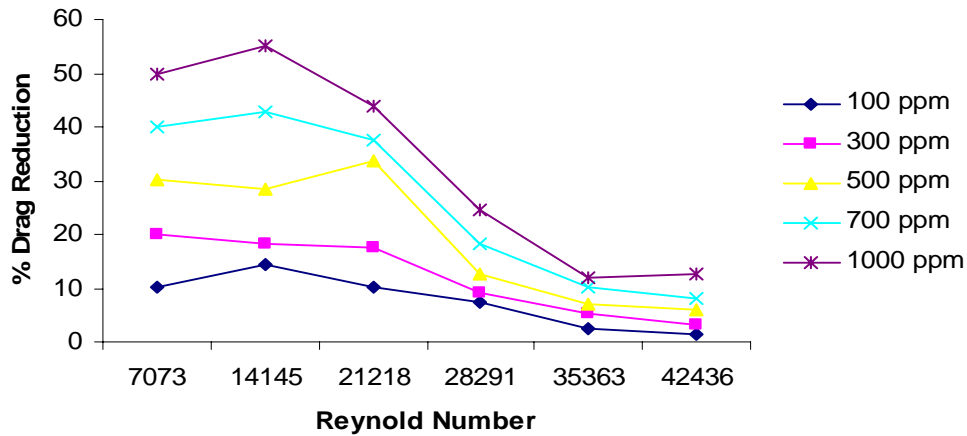


Figure 3: Effect of Reynolds number on percentage drag reduction for Okra-Natural Mucilage with different concentrations dissolved in water flowing through 0.025 m ID pipe

From the results it is also can be noticed that the percentage drag reduction increase by increasing the okra-natural mucilage concentration from 100 to 1000 ppm because of the increase of the number of surfactants molecules involved in the drag reduction process. Figure 4 and 5 also show the same behaviour. The results of this study showed that within certain surfactant type and concentration, % DR increases by decreasing the pipe diameter, which means that the surfactant will have a better media to work in smaller pipe. Refer Figure 6. Decreasing the pipe diameter means increasing the velocity inside the pipe and

by that, the turbulence will increase. Although, the flow inside pipelines is turbulent but the degree of turbulence is different. For smaller pipe, the energy absorbed by eddies in turbulence mode from the main flow will be higher than the energy that absorbed for larger pipes. By this phenomena, when the degree of turbulence become higher, the number of collisions between eddied will increase and produce smaller eddies. These collisions provide extra number of eddies to absorb energy from the flow to complete their shape.

Overcoming smaller eddies is easier by natural polymers than larger once, this is because of the amount of energy absorbed by smaller eddies is lower. This indication was supported by large number of the experimental results of the present study. In general, % Dr values for pipes of 0.015 and 0.025 m ID are close to each other.

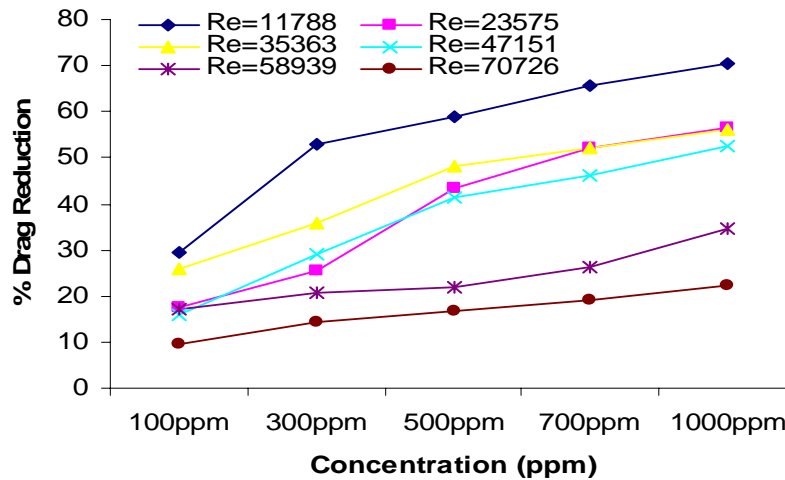


Figure 4: Effect of concentration on percentage drag reduction for Okra-Natural Mucilage dissolved in water flowing through 0.015 m ID pipe

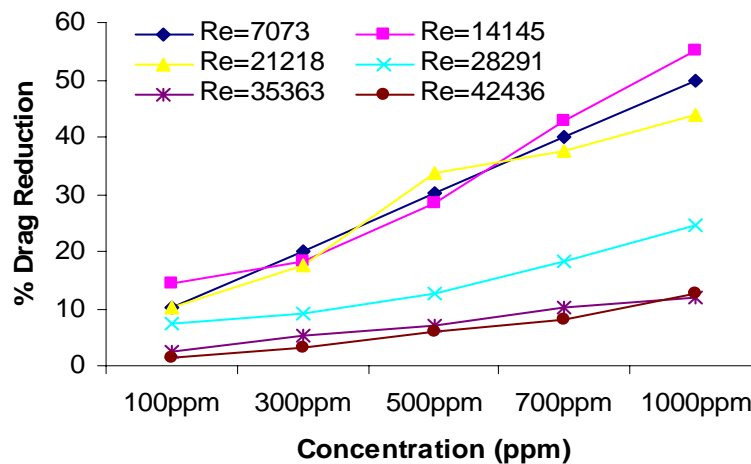


Figure 5: Effect of concentration on percentage drag reduction for Okra-Natural Mucilage dissolved in water flowing through 0.025 m ID pipe

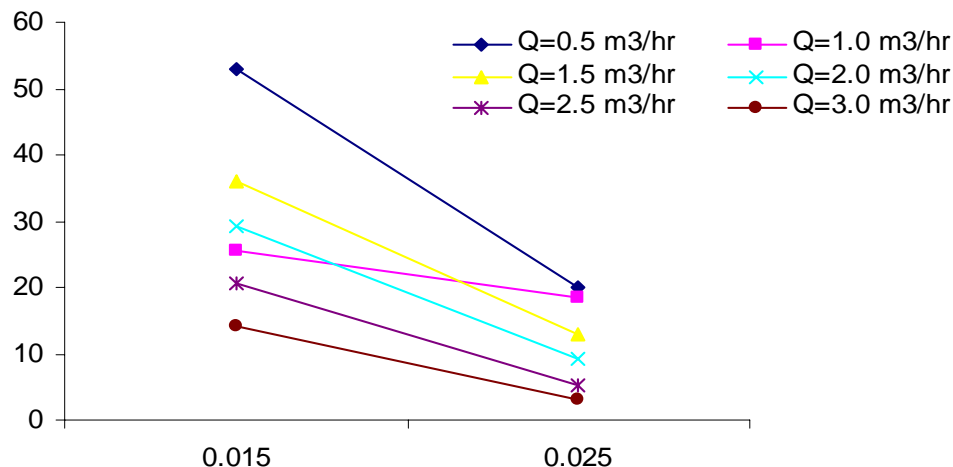


Figure 6: Effect of pipe diameter on percentage drag reduction at different volumetric flow rates, with 300 ppm concentration of Okra-Natural Mucilage dissolved in water

CONCLUSIONS

In the present investigation, it was proven that the Okra-Natural Mucilage can be used as drag reducing agent in an aqueous media and mechanism of drag reduction for polymers in turbulence flow can be adopted to explain this phenomenon. It was proven that the percentage Drag Reduction (DR%), increasing the flow rate inside the pipe and the addition concentration and reduced by increasing the pipe diameter and all that due to the changes in the turbulence media the drag reducer works with.

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